Examinees' Preference on Four Branches of Mathematics Using Multiple Matrix Sampling in Secondary Schools in Benue State, Nigeria

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ABSTRACT

The study was carried out to determine Examinees' preferences on the four branches of Mathematics using Multiple Matrix Sampling in Secondary Schools in Benue State. The study centered on examinees' preference on four branches of Mathematics using multiple matrix sampling. Two research objectives, two (2) research questions and one research hypothesis guided the study. The study adopted mixed design (ex-post facto research design and survey research design). 43243 Senior Secondary school Students made up the population while 984 were sampled using multi-stage sampling procedure. The Mathematics Preference Scale (MPS) had 4 items represented based on the four branches of Mathematics. The reliability coefficient of MPS was .78 was established using Cronbach Alpha. The hypothesis was tested at 0.05 level of significance using Analysis of Variance (ANOVA). The results revealed that, there is statistical significant difference in the students' preference in geometry, Algebra, number/numeration and statistics. Based on the results of this study, the MPS items were recommended for use in secondary schools and Mathematics teachers should make students understand that the examination bodies will set items across all the branches of Mathematics, therefore students should avoid preferences when preparing for a standardize examination.

Key words: Multiple matrix sampling, Examinees' preference, Mathematics

INTRODUCTION

Background of the Study

Mathematics is the science oriented that deals with the logic of shape, quantity, arrangement of numbers, calculation and determination of one's mean preferences. Mathematics is all around us, in everything we do in life. It is the building block for everything in our daily lives, including teaching and learning, and even in Measurement and Evaluation. The importance of Mathematics to nation building has led the Federal Government of Nigeria to make Mathematics a core subject to be offered by students at Primary and Secondary Education levels in Nigeria (NPE, 2012).

Mathematics is considered as an important subject and is taught at all level of Secondary School (SS). It has many branches in secondary school curriculum which include Geometry, Number/numerations, Algebra, Statistics, and commercial Mathematics and among others.

Geometry is derived from two Latin words, Geo and Metron meaning earth and measurement. Bashir and Maude (2022) defined Geometry as a branch of Mathematics that deals with the properties of shapes, angles, plane figures, solid shapes and its theorems. It is a study that finds out the length, area, volume of different plane and solid figures.

Algebra is a branch of Mathematics where unknown quantities operated with the stated numbers. The unknown quantities are represented by letters of the English alphabet such as X, Y, A, B, and symbols among others. Bhairab (2017) asserted that the use of letters help to generalize the formulae and rules and it helps to find the unknown missing values in the Algebraic expressions and equations. This branch of Mathematics is found to be the foundation that deals with the unknowing quantity.

Number/numeration deals with numbers and basic operations such as addition, subtraction, multiplication and division. This branch of Mathematics also help in counting items, things in numbers or symbols. Statistics is a branch of Mathematics that deals with the collection of data, arrangement of data, analysis and interpretation for dependable result and recommendations. Statistics is simply defined as the study and manipulation of data (Imoko & Agwagah, 2016). It deals with the analysis and computation of numerical data.

Despite the importance and many branches attached to Mathematics as a key subject in realizing any nation's scientific and technological aspiration, it has experienced a flood of persistent failure (Imoko & Agwagah, 2016). In view of this, Kurumeh (2012) noted that the study of Mathematics has been ineffective in meeting the higher educational goal and national development. It is as a result of poor achievement in School Based Assessment and Senior Secondary school Certificate Examination (West African Examination Council (WAEC) and National Examination Council (NECO)) in Mathematics

that lead many researchers to be active in the research in order to identify what could have been the causes of students' poor achievement in Mathematics. The NECO results of students in Nigeria showed that some students performed poorly in Mathematics. In years 2019, 2020, 2021, 2022 and 2023, the percentage pass with credit and above were 29.24%, 30.01%, 34.77%, 26.85% and 31. 57% respectively (Bashir & Maude, 2022 & NECO chief Examiner, 2023). The trend of achievement is the same in WAEC results. In the years 2019, 2020, 2021, 2022 and 2023 results were dropped consecutively in credit level (A1-C6); 40.52%, 38.15%, 30.11%, 32.23% and 32.16% respectively (Bashir & Maude, 2022 & WAEC Chief Examiner, 2023). Based on the observed rates of students' performance, Mathematics as a core subject showed a fluctuating trend in the performance of candidates over many years. WAEC examiner's report (2023) specifically identified the following factors as reasons for students' low achievement: shallow knowledge of some basic principle, concepts and appropriate application of formulae; confusion in similar topics. Some researchers (Might, Kofi & Kodzo, 2018) have identified teachers' qualification, lack of instructional materials, teaching methods, test items and learners' characteristics as the factors affecting students' achievement. However, less emphasis is being laid on the examinees' choices on the topics. Most of students preferred most branch of Mathematics than others. There is less research work on whether students have difficulty on one branch of Mathematics to other parts. Thus, this present study determined examinees' preference on the four branches of Mathematics using multiple matrix sampling. Preference means have a strong choice on one something best known and like. Students it seems that students prefer some branches than others. Multiple matrix sampling will be of help to subdivide mathematics topics in order to examine students' preference in a larger population.

Multiple Matrix Sampling (MMS) is a new statistical procedure in the psychometric literature that serves as an attempt for assessing the examinees in the broad topics of the Mathematics curriculum during testing while minimizing the testing time per child. Anta (2020) defined Multiple Matrix Sampling as a statistical designs in which a set of **K** items (items population) is subdivided into **t** subsets (group of tests) containing **k** items each with each subset administered to **n** Examinees selected randomly from the population of **N** Examinees. In this study, the researcher is interested in applying multiple matrices sampling by adapting Mathematics as a subject and then subdivided into subsets in topics form; Geometry, Algebraic, Number/Numeration and Statistics. These subsets, examinees are constructively expected to prefer the most branch or branches of Mathematics among a larger population of students.

There are some considerations to be made in the applications of the multiple matrixes sampling. These include: the number of subsets among examinees and items, the number of items per subset and the number of examinees administered to each subset (Anta, 2020). These variables can be manipulated to create several multiple matrix sampling plans. These may be in the form of the number of available examinees, time available and the cost of materials. Popham in Anigbo (2015) identified two types of matrix sampling. These are items multiple matrix sampling type and genuine multiple matrix sampling type.

The genuine multiple matrix sampling design is a matrix sampling where the population items of an instrument is subdivided into subsets containing items each that represent each group based on content. Anigbo (2015) defined genuine multiple matrix sampling design as the situation where the students or groups of students are sampled so that only some of the students or groups take any two subset test at a time without attending to remaining subsets.

The items multiple matrix sampling type refers to the situations where subsets of the test package are administered to every student or group of students in a defined population. This can be done in two ways: the first is called examinees-items sampling (linear multiple matrix sampling). Takis (2015) considered examinees-items sampling as students sampled randomly are administered to one of the subsets from sampled items without taking any items in common. The second method is called Partial multiple Matrix Sampling. This is the situation where a subset of the package is selected to be common to all the students and the group of students with the remaining subsets that are matrix sampled. The common subset serves as an anchor and helps to improve comparability of students or group results, while the matrix- sampled items increase content coverage per testing time. In this case, both items and students or groups are sampled.

In this study the researcher adopted examinees-items sampling (linear multiple matrix sampling) to determine examinees preference in four branches of Mathematics. There is, however, implication associated with the design. This relate to reliability of the students responses after a repeated measured.

Reliability refers to how consistent responses are. Nor (2016) defined reliability of an instrument as the measure of stability or internal consistency of an instrument in measuring certain concepts. It is considered as the extent to which scores are free from measurement errors. Generally, a test with more items tends to yield increased reliability while shorter tests yield lower reliability.

The study centered on two theories: Classical Test Theory (CTT) and Item Response Theory (IRT). CTT was concerned on the results of the preference scale while IRT was concerned on individual item of scale. There are literatures whose works centered among the related subjects. Adeleke (2018) who found that there was significant difference among the students preference in Mathematics topics. The findings further expanded that numeration, algebraic process and statistics were found most preferred Mathematics topics while bearing, probability and mensuration are most dislike Mathematics topics among secondary school. Also Kaplan and Dan (2016) found that there is significant preference in the original marginal distribution and context questionnaire development using matrix sampling.

It is on this note that the researcher deemed it fit to carry out this study by dividing the adapted Mathematics subject and subdividing it into Geometry, Algebra, Arithmetic and Statistics to determine the most preferred branch of Mathematics among students. Hence, the study is on the Examinees' preference of the four branches of Mathematics using Multiple Matrix Sampling in Secondary Schools in Benue State.

Statement of the Problem

 Students require a credit pass in Mathematics for admission in tertiary institution irrespective of the course to be studied. This means that Mathematics is compulsory for all students before they can be admitted into tertiary institution. In view of this, students are expected to cover and master all the branches of Mathematics that form parts of the Senior Secondary School curriculum before sitting for any Senior Secondary School Examinations and have credit pass in it.

It was however observed that the failure rate of the students in WAEC/NECO is high (Bashir & Maude, 2022 & WAEC chief Examiner, 2023). In most cases, students will only attempt some items on Algebra and Statistics but have no attempt on Geometry items, Some Examinees were willfully violating the instructions in order to make it on one part of Mathematics items that is best known or preferred by them. This raised some questions on what could have been the problem of students' poor achievement in Mathematics. Is it that teachers are covering only the Mathematics preferred by them? Could it be that the teachers/students are better in Algebra than Geometry or Statistics or vice versa? Could it be that Mathematics has some abstract parts that students find it difficult to understand that cause the preferred one branch than another? The reason may be that students may not understand some parts of Mathematics as regards to other branches. Since the standard examination needs mastery of the whole course contents, for that reason, choice of responding to items preferably may be a potent factor that causes examinees' poor achievement in Mathematics.

Therefore, the researcher adapted Multiple Matrix Sampling (MMS) to determine examine most preferred branches. These Mathematics branches include: Geometry, Algebra, Numeration and Statistics. In addition, this study will helps to identify Examinee strengths and weaknesses on the four branches of the Mathematics.

Objective of the Study

The study sought to determine the examinees' preference of the four branches of Mathematics using Multiple Matrix Sampling in Benue state of Nigeria. Specifically, the study sought to determine:

1. the reliability coefficients of Mathematics preference scale on Geometry, Algebra, Number/Numeration and Statistics items using Multiple Matrix Sampling.

2. the students most preferred four branches (Geometry, Algebra, Number/Numeration and Statistics) on the branches of Mathematics.

Research Questions

The following research questions were raised to guide the study:

1. What are the reliability coefficients of Mathematics preference scale on Geometry, Algebra, Number/Numeration and Statistics items using Multiple Matrix Sampling?

2. What is the students most preferred four branches (Geometry, Algebra, Number/Numeration and Statistics) items?

 Hypothesis

The hypothesis was formulated and tested at 0.05 level of significance.

1. There is no significant difference in the preference of examinees in Geometry, Algebra, Number/Numeration and Statistics using Multiple Matrix Sampling.

Method

The study adopted survey research design. The population of the study comprised of 43243 Senior Secondary students in in Benue State.

The sample size of 984 was used. The sample size was drawn using multi-stage sampling technique. The study has self – developed scale called ''Mathematics Preference Scale (MPS). The reliability co-efficient of MPS was .78 using Cronbach Alpha. Cronbach Alpha was used to answer research question 1 and Mean and standard deviation were used to answer the research questions 2. ANOVA was used to test the hypothesis at 0.05 level of significance.

RESULTS

Table 1 answer the research question 1

Table 1: **Cronbach's Alpha coefficient of the Mathematics Preference Scale of four Branches of Mathematics.**

Cronbach's Alpha	Cronbach's Alpha based on standardized items	no; of items
.73	.78	4

Table 2 answer the research question 2

Table 5: Mean Ratings of the students' preference in Geometry, Algebra, Numeration and Statistics (N=984)

S/N	Branch	N	$\bar{x}$	SD	Remark
1	Geometry	246	1.80	.84	SP
2	Algebra	246	3.08	1.05	P
3	Numeration	246	2.98	1.10	P
4	Statistics	246	2.59	1.03	P

N = Sample size, $\bar{x}$ = Mean, SD = Standard Deviation, MP= Most preferred, P=Preferred, SP= Slightly Preferred

Four Mathematics Branches
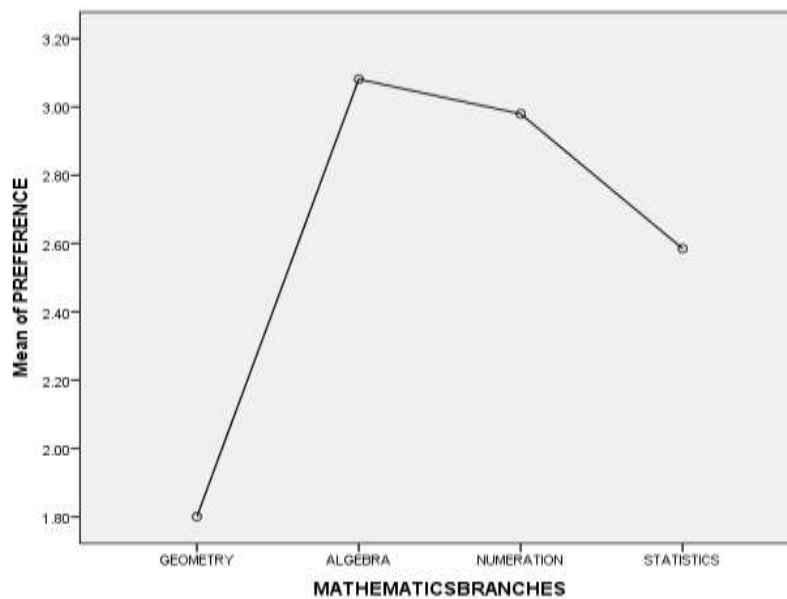
Fig.1: Means Plots on the students' preference in Geometry, Algebra, Numeration and Statistics

Table 3 was used to test hypothesis 1

Table 3: One-way Analysis of Variance (ANOVA) on the Preferences of Examinees in Geometry, Algebra, Numeration and Statistics

Groups	Sum of Squares	Df	Mean Square	F	A	Sig.
Between Groups	249.48	3	83.16			
Within Groups	996.22	980	1.02	81.77	0.05	.000
Total	1245.70	983				

(P< 0.05) α =level of significance

Maths Branches (I)	Four Maths Branches (J)	Mean Diff. (I-J)	Sig.	95% Confidence interval	
				Lower Bound	Upper Bound
Geometry	Algebra	-1.28049*	.000	-1.5144	-1.0465
	Numeration	-1.17886*	.000	-1.4128	-.9449
	Statistics	-.78455*	.000	-1.0185	-.5506

Algebra	Geometry	1.28049[*]	.000	1.0465	1.5144
	Numeration	.10163	**.679**	-.1323	.3356
	Statistics	.49593[*]	.000	.2620	.7299
Numeration	Geometry	1.17886[*]	.000	.9449	1.4128
	Algebra	-.10163	**.679**	-.3356	.1323
	Statistics	.39431[*]	.000	.1604	.6283
Statistics	Geometry	.78455[*]	.000	.5506	1.0185
	Algebra	-.49593[*]	.000	-.7299	-.2620
	Numeration	-.39431[*]	.000	-.6283	-.1604

P< 0.05

Fig 2: POST HOC Tests on the Preference of Examinees in Geometry, Algebra, Numeration and Statistics

FINDINGS

The findings revealed that the reliability coefficient on the Mathematics Preference Scale items were found highly reliable. This finding is similar to the value range of reliability index determined by Tarkis (2015) whose results showed that the items had a high reliability coefficient of the various subsets (0.84, .67, .71 and .65). Furthermore, the findings were in similar range value of Opera, Ijeoma and Magnu (2017) that found the reliability index of achievement test of 0.73. These values of reliability indices were considered high reliable. The high reliability index indicated in the present study was not surprising because the instruments have adequately undergone face, construct validation before administration and the items were rated base on four branches of Mathematics using multiple matrix sampling.

The result of the analysis showed that there is statistical significant difference in the mean preference of examinees in Geometry, Algebra, Numeration and Statistics using multiple matrix sampling. This finding correlates with Adeleke (2018) who found that there was significant difference among the students preference in Mathematics topics. The findings further expanded that numeration, algebraic process and statistics were found most preferred Mathematics topics while bearing, probability and mensuration are most dislike Mathematics topics among secondary school. The finding also confirmed by Kaplan and Dan (2016) that there is significant preference in the original marginal distribution and context questionnaire development using matrix sampling. The current study found that algebra and number/numeration were found highly preferred, followed with statistics but geometry was found slightly preferred.

Conclusion

Based the findings of study, the study concluded that the MPS was found reliable and the students preferred better in algebra and number/numeration, followed with statistics and had a slight preferences in geometry and this causes the students poor achievement in Mathematics.

Recommendations

Sequel to the above findings from this study, the following recommendations are made:

The reliability coefficient of the instrument should always be established before use.

Teachers, researchers and curriculum planners should make students understand that the examination bodies will be set across all the branches of Mathematics to avoid preferences when preparing for a standardize examination.

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